US009656400B2

(12) **United States Patent**
**Krenik**

(10) **Patent No.: US 9,656,400 B2**
(45) **Date of Patent: May 23, 2017**

(54) **HAIR CUTTING TECHNIQUES FOR AUTOMATED HAIR CUTTING SYSTEM**

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( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 8 days.

(21) Appl. No.: **14/534,411**

(22) Filed: **Nov. 6, 2014**

(65) **Prior Publication Data**

US 2015/0059187 A1 Mar. 5, 2015

**Related U.S. Application Data**

(63) Continuation-in-part of application No. 14/086,497, filed on Nov. 21, 2013, now abandoned.

(60) Provisional application No. 61/901,093, filed on Nov. 7, 2013, provisional application No. 61/925,567, filed on Jan. 9, 2014, provisional application No. 61/728,851, filed on Nov. 21, 2012, provisional application No. 61/780,086, filed on Mar. 13, 2013.

(51) **Int. Cl.**

| | |
|---|---|
| ***B26B 19/38*** | (2006.01) |
| ***B26B 19/42*** | (2006.01) |
| ***B26B 21/40*** | (2006.01) |

(52) **U.S. Cl.**

CPC ..... ***B26B 19/388*** (2013.01); ***B26B 19/3806*** (2013.01); ***B26B 19/3846*** (2013.01); ***B26B 19/42*** (2013.01); ***B26B 21/4081*** (2013.01); *Y10T 83/141* (2015.04)

(58) **Field of Classification Search**

CPC ... B26B 19/388; B26B 21/4081; B26B 19/42; B26B 19/3806; B26B 19/3846; Y10T 83/141

See application file for complete search history.

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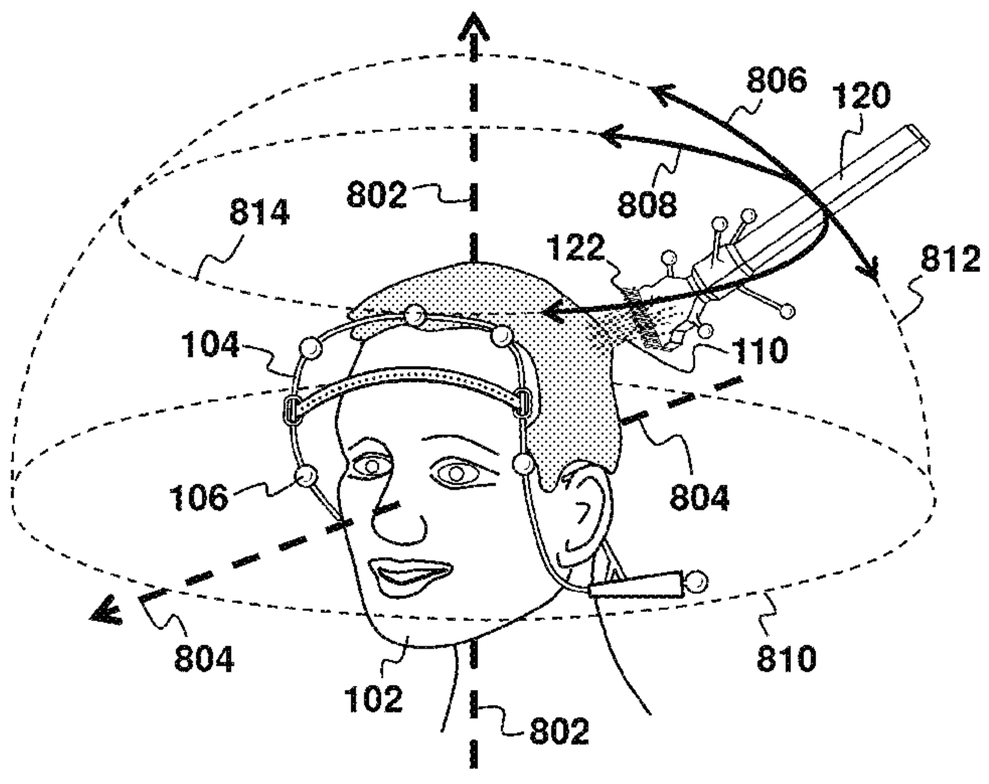
(57) **ABSTRACT**

Various aspects of automated grooming systems and cutting devices are disclosed. One embodiment of an automated grooming system comprises a computing device; a cutting device comprising a handle having a proximal and distal end and a cutting head positioned near the distal end of the handle; and a plurality of positioning sensors configured to send signals to the computing device relaying the position of the cutting head relative to a surface having hair extending therefrom. The computing device may be configured to receive the signals from the positioning device and prepare instructions for actuation of the cutting device. In some embodiments, the cutting device comprises a processor configured to receive the prepared instructions from the computing device and actuate the cutting device according to the prepared instructions.

**20 Claims, 9 Drawing Sheets**



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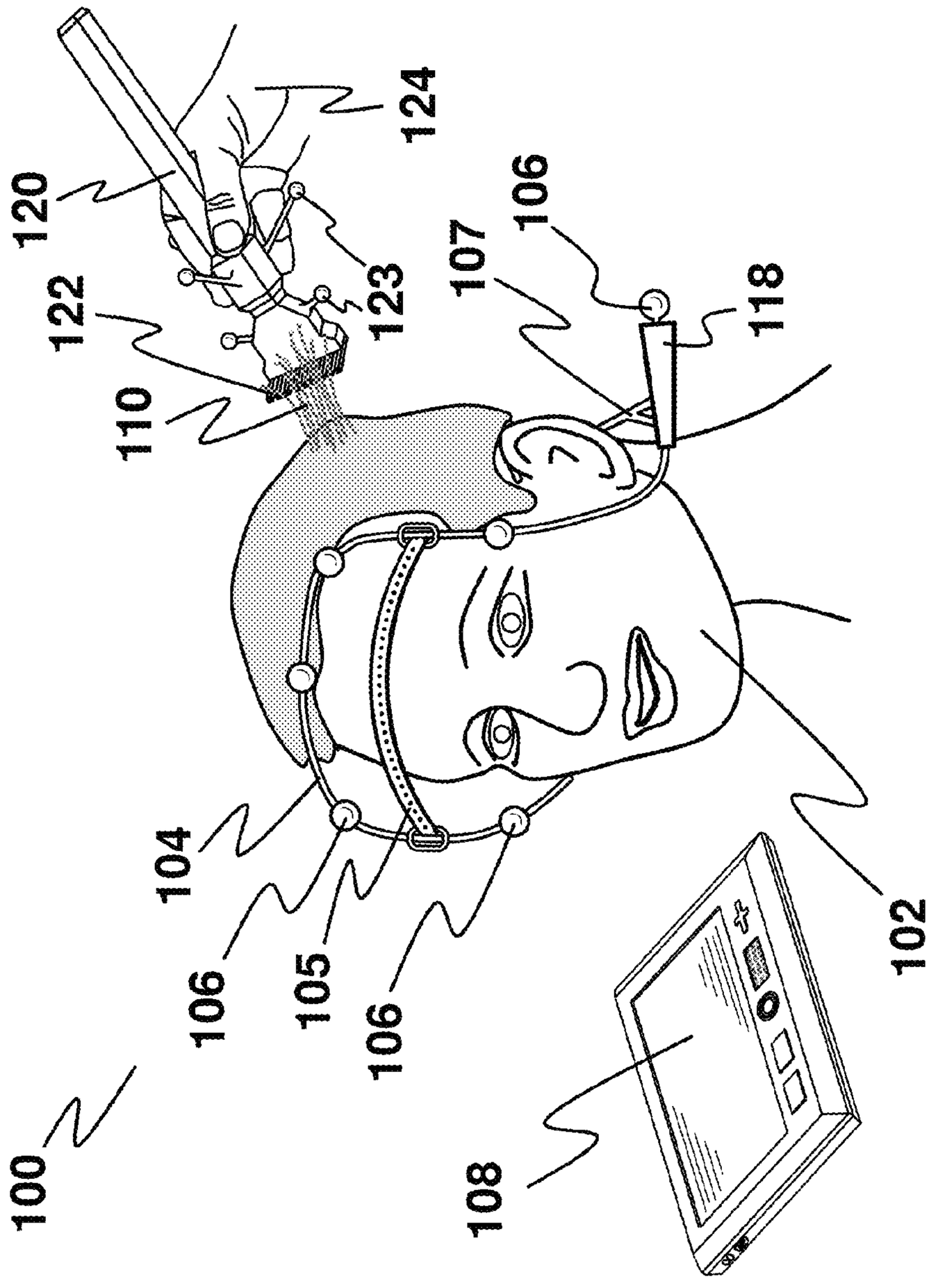


FIG. 1

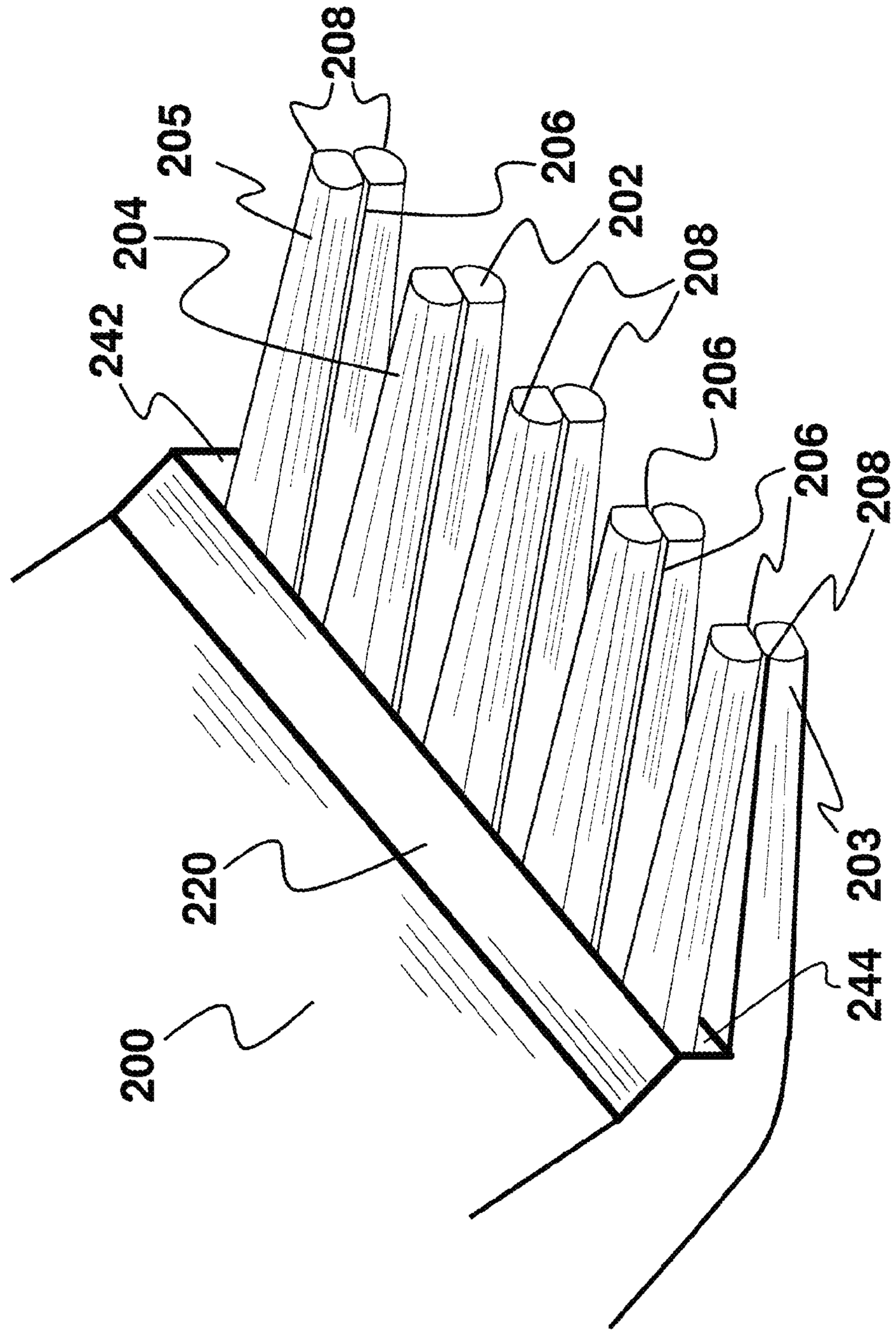


FIG. 2

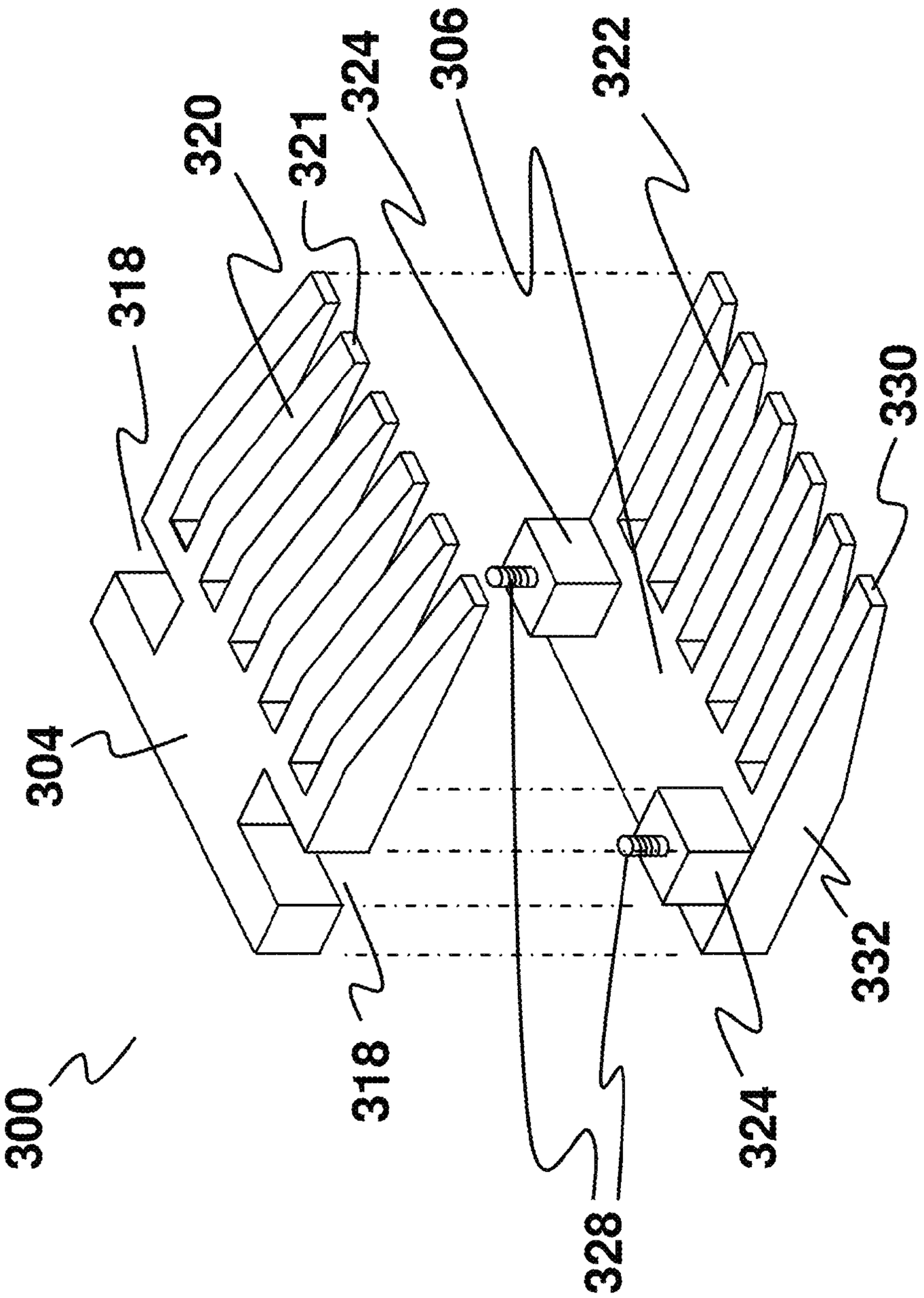


FIG. 3

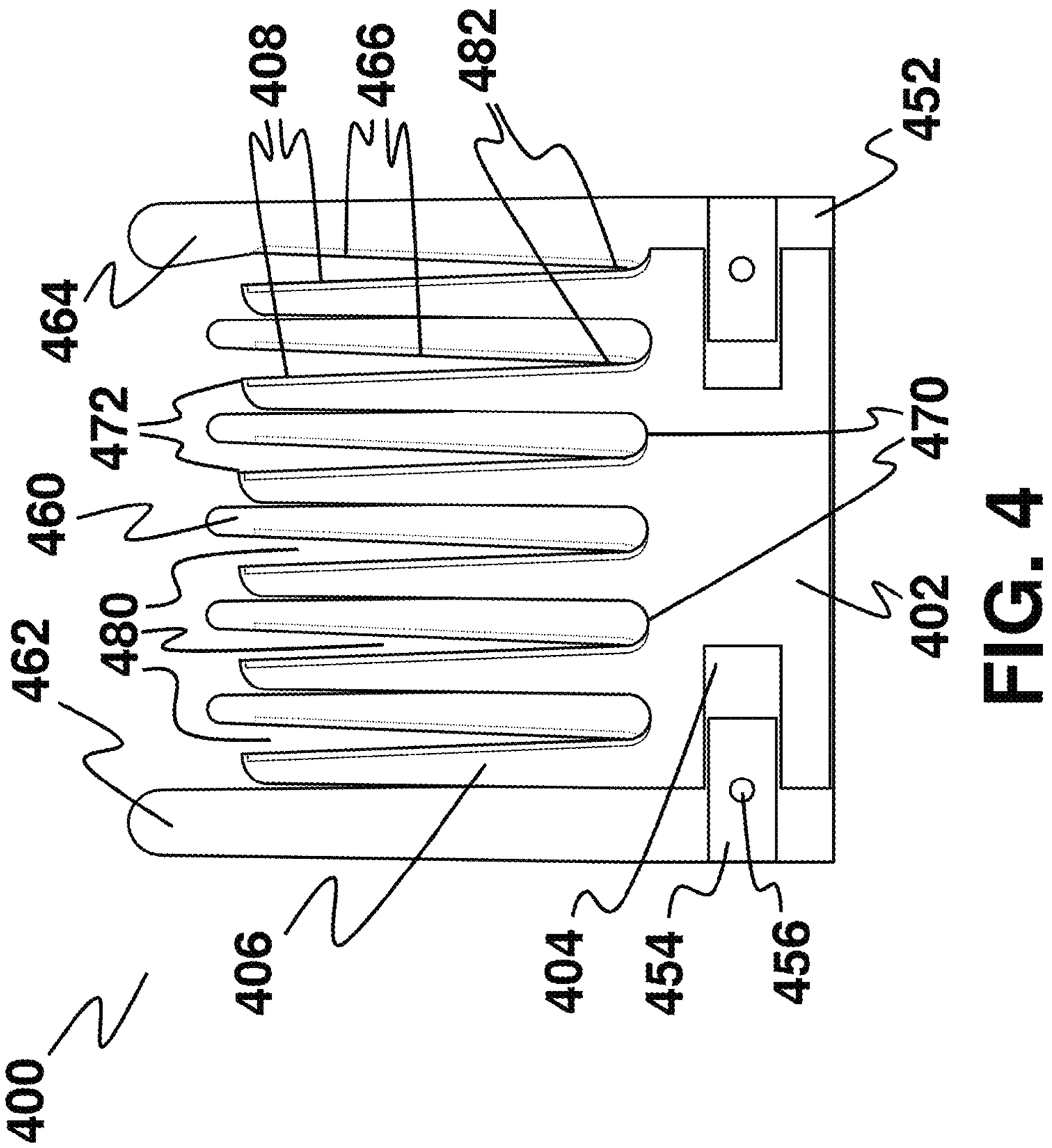


FIG. 4

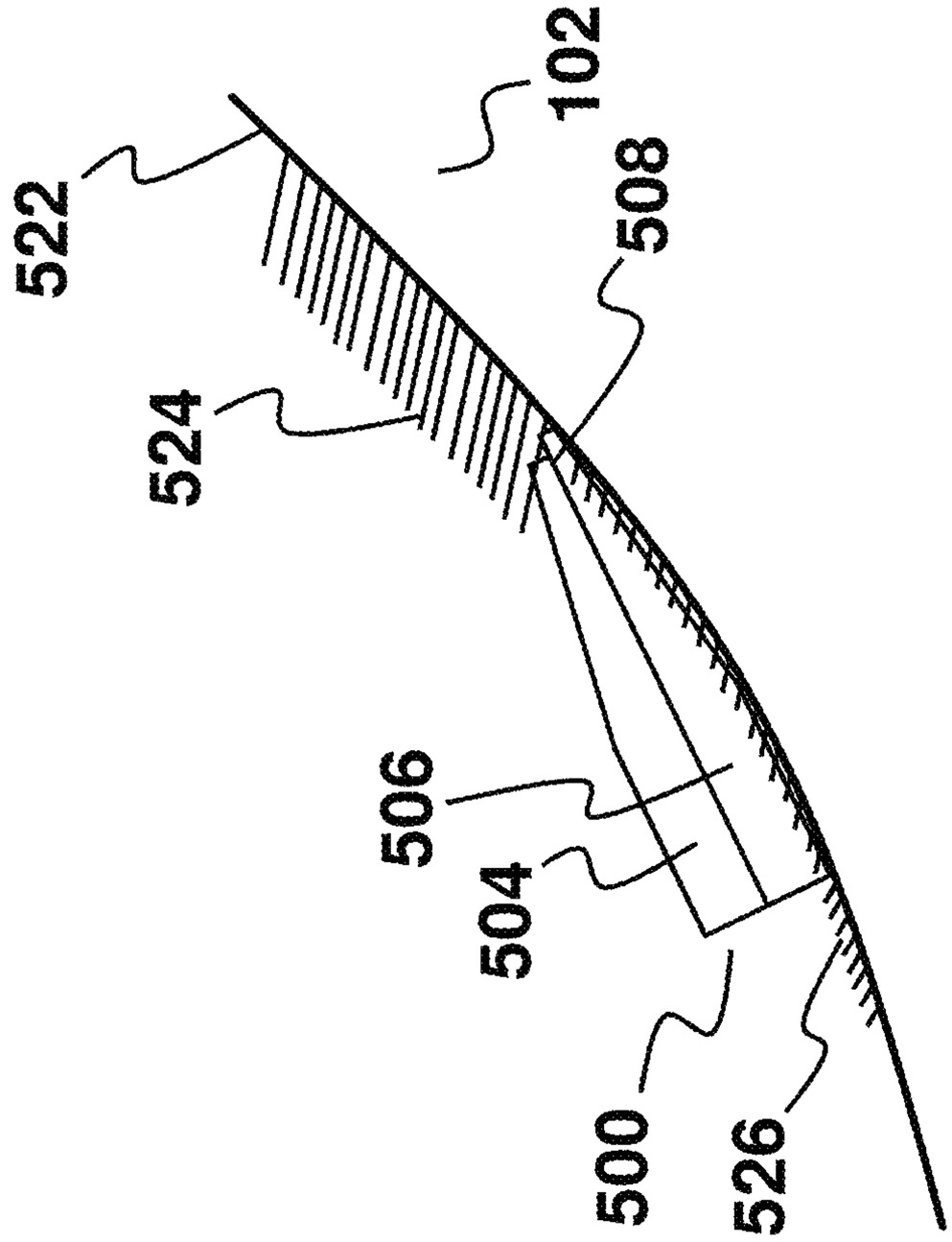


FIG. 5

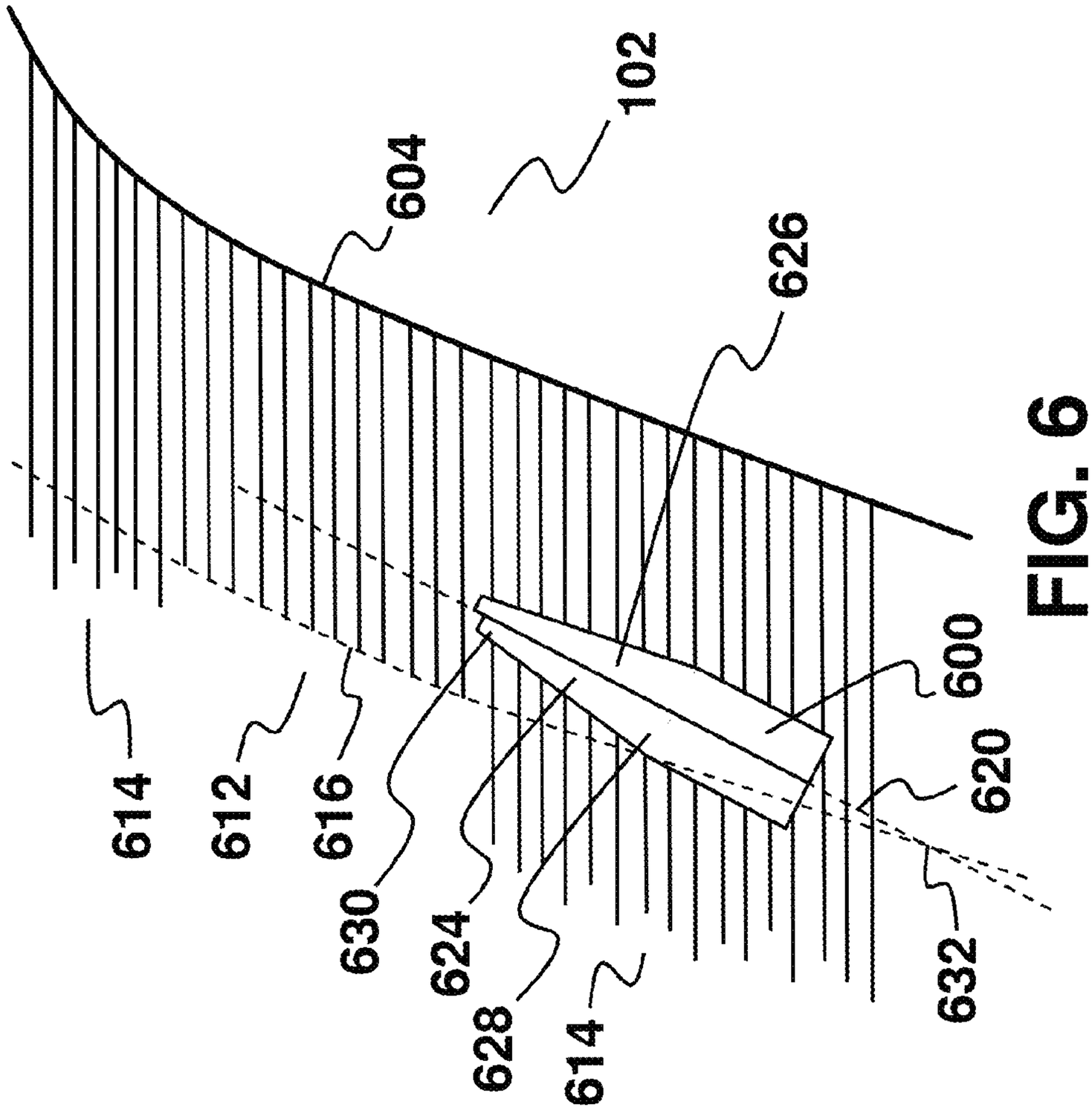


FIG. 6

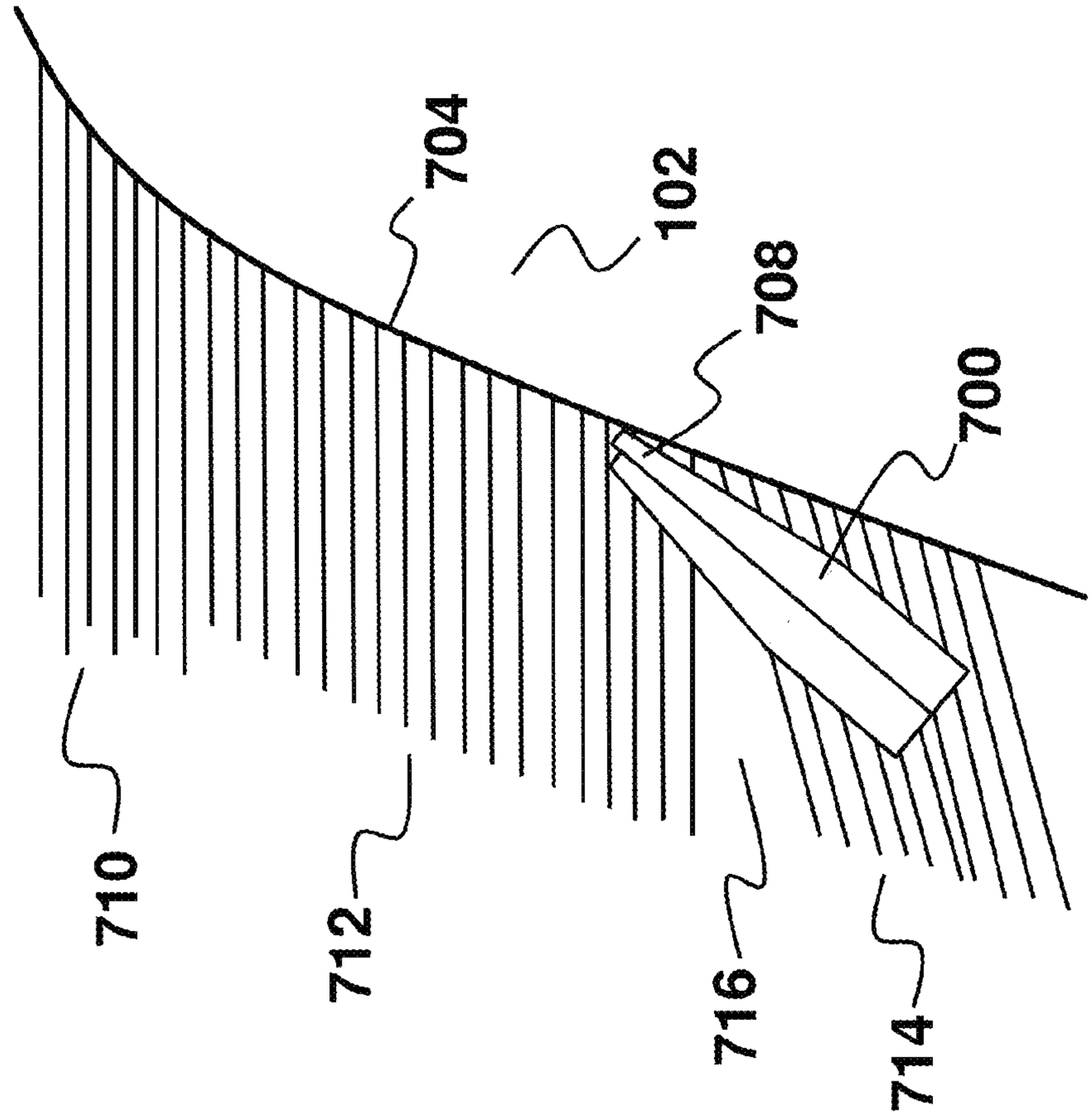


FIG. 7

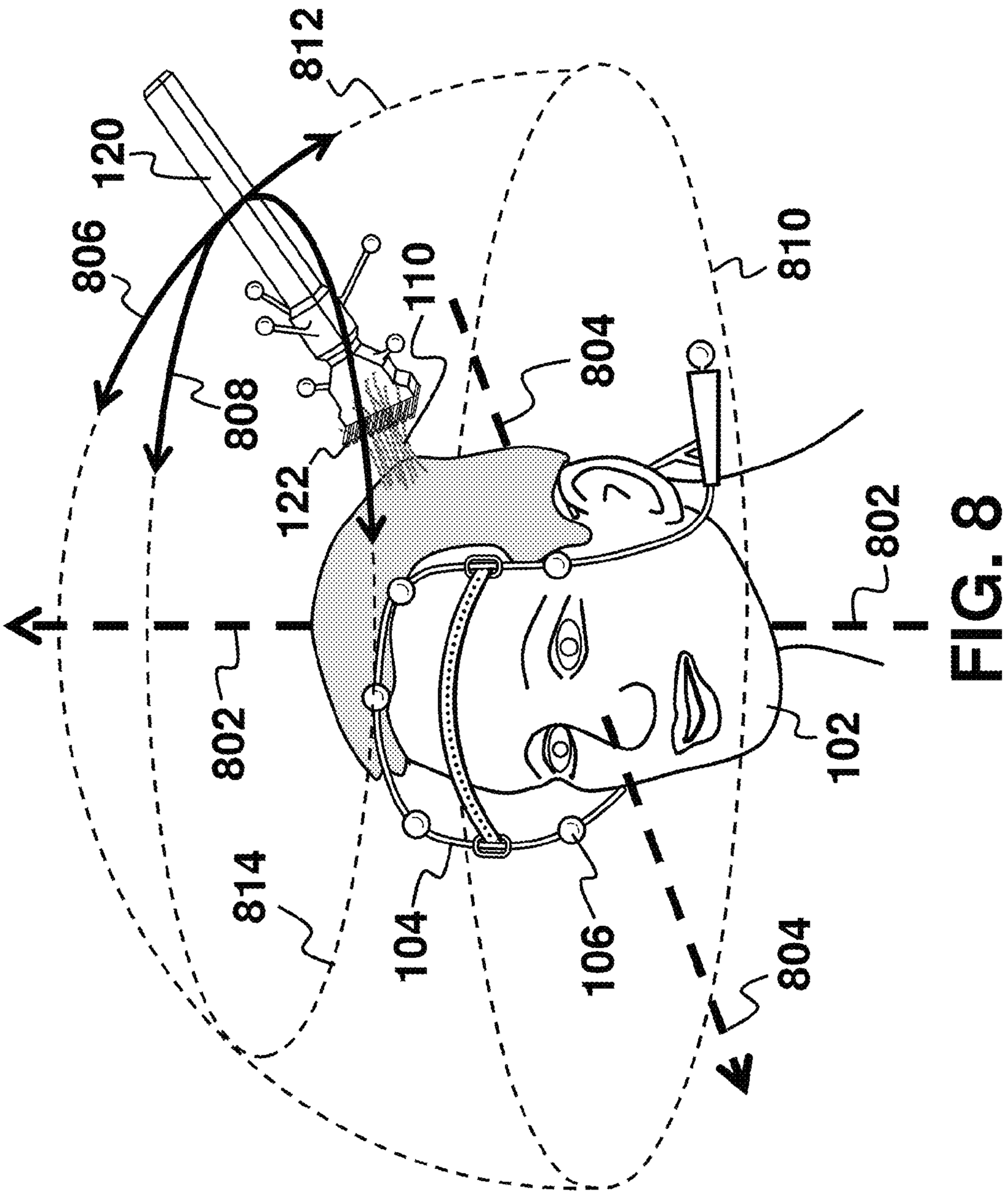


FIG. 8

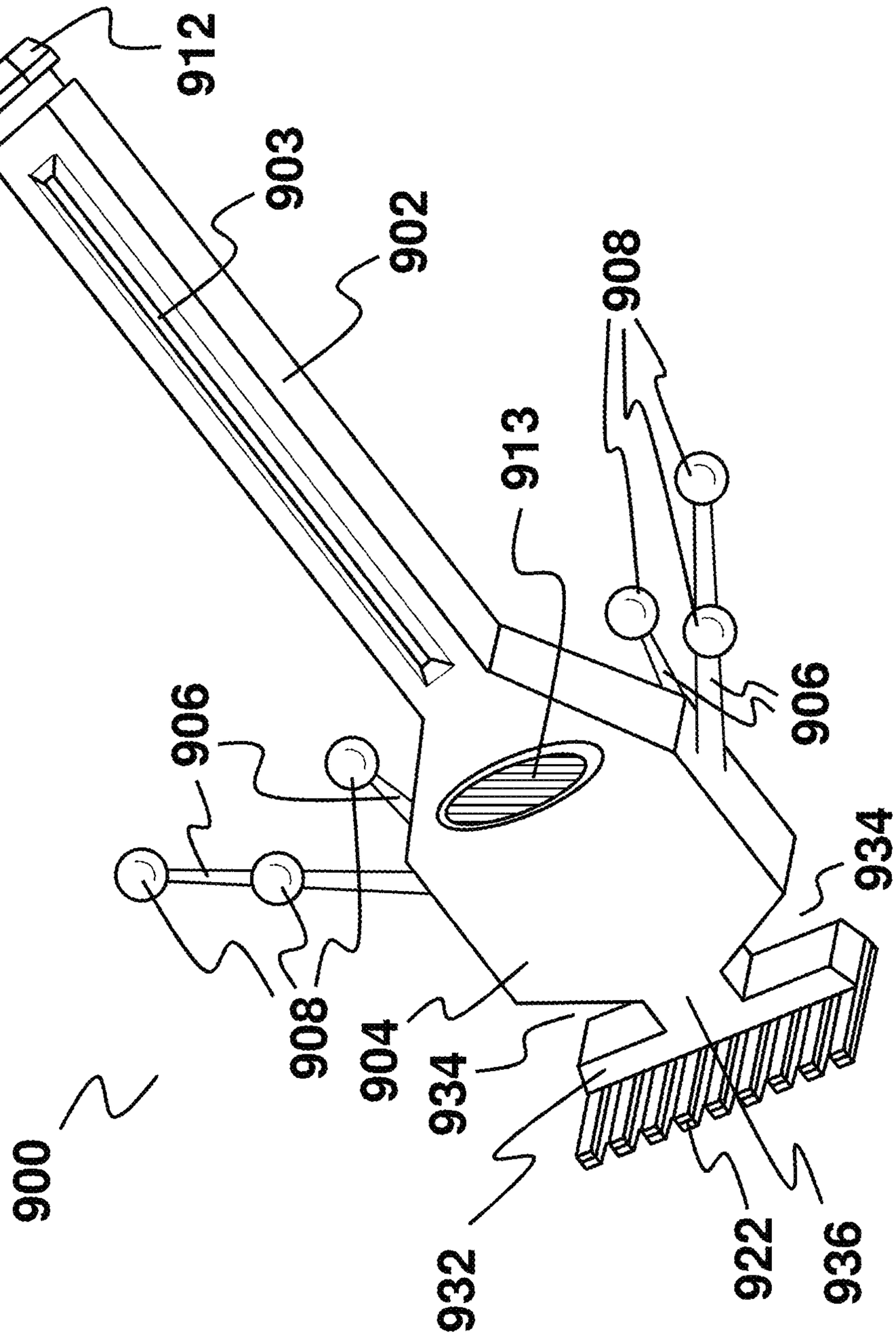


FIG. 9

# HAIR CUTTING TECHNIQUES FOR AUTOMATED HAIR CUTTING SYSTEM

## CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority to U.S. Provisional Application Ser. No. 61/901,093, filed by Matthew W. Krenik on Nov. 7, 2013, entitled "Positioning Methods for Automated Hair Cutting System"; and U.S. Provisional Application Ser. No. 61/925,567, filed on Jan. 9, 2014, entitled "Hair Cutting Techniques for Automated Hair Cutting System"; and is a continuation-in-part application of U.S. patent application Ser. No. 14/086,497 filed by Matthew W. Krenik on Nov. 21, 2013, entitled "Sensing and Control Techniques for Automated Hair Cutting System," which claims priority to U.S. Provisional Application Ser. No. 61/728,851, filed by Matthew W. Krenik on Nov. 21, 2012, entitled "Cutter Head Sensing and Control for Automated Hair Cutting System;" and U.S. Provisional Application Ser. No. 61/780,086, filed by Matthew W. Krenik on Mar. 13, 2013, entitled "Techniques for Automated Hair Cutting System," all of which are commonly owned with this application and the contents all are incorporated herein by reference.

## TECHNICAL FIELD

The present disclosure relates generally to grooming systems and methods, and more specifically, to a cutter head and improvements thereof used in conjunction with an automated system, such as an automated hair cutting system.

## BACKGROUND

International application number PCT/US12/70856, filed by Matthew W. Krenik on Dec. 20, 2012, entitled "Automated Hair Cutting System and Method of Operation Thereof," (hereinafter "Krenik '856") provides a description of some embodiments of automated hair cutting systems. These systems operate by determining the position and/or orientation of a hair cutting device relative to a user receiving a haircut. Hair may be collected in a cutter head and extended for cutting to a desired length. Through electronic measurements and computational analysis, the location of where hair on the scalp of a user is collected into a cutter head may be determined and as hair is extended and slides through a cutter head, its length may be substantially determined so that a cutter head may be actuated at a certain time to cut hair.

Krenik '856 identifies multiple ways that an automated hair cutting system may be used to cut hair, including how automated hair cutting systems may be applied to cut hair so that a wider range of styles, more accurate or otherwise desirable results, or other benefits may be achieved in providing a user with a desirable haircut.

U.S. patent application Ser. No. 14/051,201 filed by Matthew W. Krenik on Oct. 10, 2013, entitled "Cutter Head for Automated Hair Cutting System," (hereinafter "Krenik '201") provides embodiments of cutter heads suitable for use with automated hair cutting systems. The embodiments of hair cutting devices shown in the present disclosure may use the cutter heads shown in Krenik '201, the cutter heads described in the present disclosure, or other suitable cutter heads. U.S. patent application Ser. No. 14/086,497 filed by Matthew W. Krenik on Nov. 21, 2013, entitled "Sensing and Control Techniques for Automated Hair Cutting System," (hereinafter "Krenik '497") provides embodiments of sensing, actuation, and control systems for cutter heads for automated hair cutting systems. The embodiments of automated hair cutting systems shown in the present disclosure may utilize the sensing, actuation, and control systems shown in Krenik '497, those described in the present disclosure, or other suitable sensing, actuation, and control systems. U.S. patent application Ser. No. 14/156,817 filed by Matthew W. Krenik on Jan. 16, 2014, entitled "Positioning Device for Automated Hair Cutting System," (hereinafter "Krenik '817") provides embodiments of positioning devices for automated hair cutting systems. The embodiments of positioning devices shown in the present disclosure may utilize the positioning devices shown in Krenik '817, those described in the present disclosure, or other suitable positioning devices.



## SUMMARY

Disclosed herein are various aspects of cutting devices for use with automated hair cutting systems. In one embodiment, the cutting device may comprise a handle having a proximal and distal end; a cutting head positioned near the distal end of the handle. The cutting head may comprise a cutting instrument, said cutting instrument having a plurality of cutter knives, said cutter knives configured having a sharp angled edge on at least one side thereof; and a comb coupled proximate the cutting instrument, said comb having a first and second end and a plurality of teeth positioned therebetween, wherein the plurality of teeth and at least one of the first and second end have a sharp angled edge on an inner side thereof; wherein the sharp angled edges of the cutter knives are configured to engage the sharp angled edges of the plurality of teeth when the cutting instrument is actuated. The cutting device may also comprise at least one positioning sensor configured to interact with the automated hair cutting system, said interaction comprising at least one signal indicating the position of the cutting head relative to a surface having hair extending therefrom.

In another embodiment, there may be disclosed an automated grooming system, comprising a computing device; and a cutting device. The cutting device comprises a handle having a proximal and distal end; a cutting head positioned near the distal end of the handle, the cutting head comprising a cutting instrument, said cutting instrument having a plurality of cutter knives, said cutter knives configured having a sharp angled edge on at least one side thereof; and a comb coupled proximate the cutting instrument, said comb having a first and second end and a plurality of teeth positioned therebetween, wherein the plurality of teeth and at least one of the first and second end have a sharp angled edge on one side thereof; and wherein the sharp angled edges of the cutter knives are configured to engage the sharp angled edges of the plurality of teeth when the cutting instrument is actuated. The automated grooming system may also comprise at least one positioning sensor configured to interact with the computing device, the interaction including at least one signal indicating the position of the cutting head relative to a surface having hair extending therefrom.

In yet another embodiment, there may be an automated grooming system, comprising a computing device; a cutting device comprising a handle having a proximal and distal end and a cutting head positioned near the distal end of the handle; and a plurality of positioning sensors configured to send signals to the computing device relaying the position of the cutting head relative to a surface having hair extending therefrom. The computing device may be configured to

receive the signals from the positioning device and prepare instructions for actuation of the cutting device.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an environmental view of one embodiment of an automated hair cutting system;

FIG. **2** is a perspective view of one embodiment of a cutter head according to the present disclosure;

FIG. **3** is an exploded view of another embodiment of a cutter head according to the present disclosure;

FIG. **4** is a top view of another embodiment of a cutter head according to the present disclosure;

FIG. **5** is an environmental view of a hair cutting operation using a cutter head according to the present disclosure;

FIG. **6** is another environmental view of a timed hair cutting operation using a cutter head according to the present disclosure;

FIG. **7** is yet another environmental view of a hair cutting operation using one embodiment of a cutter head according to the present disclosure;

FIG. **8** is a perspective view of another embodiment of an automated hair cutting system using an axis system; and

FIG. **9** is a perspective view of a cutting device according to the present disclosure.

## DETAILED DESCRIPTION

Automated hair cutting systems provide a wide range of flexibility for how hair may be collected in a cutter head, extended to a desired length, and cut. The present disclosure provides enhanced systems, techniques, and methods for how automated hair cutting systems may be enhanced and applied in additional ways to achieve results, including improved ways in which a user and an automated hair cutting system may interact. A cutter head of a hair cutting device may be tilted so that the cutter head tips slide over a user's scalp while the cutter head is actuated so that a closer shaving action than may otherwise be possible is achieved. A user may be guided to orient a hair cutting device so that hair collected near the base region of a cutter head (near where the cutter knives and comb teeth first meet when the cutter head is actuated to cut hair) may be cut first and hair near the tips of the cutter head may be cut later, so that hair is cut accurately as the hair cutting device is manipulated to extend hair for cutting. In this way, hair collected in a cutter head may be cut to different lengths as actuation of a cutter head may be coordinated with extension of hair through the cutter head so that hair is substantially optimally cut to its desired length. Further, hair may be cut to conform to various gradients and contours of hair lengths associated with various regions of a user's scalp, according to a desired hair style. The tips of a cutter head may also be inserted into hair, possibly along a part that has been combed into the hair, so that thinning, feathering, or layering effects may be produced.

Operation of an automated hair cutting system may involve a user interacting with an electronic computing device, a positioning device, a hair cutting device, and possibly with other elements that may be present in some embodiments of automated hair cutting systems. Users of automated hair cutting systems may prefer to observe themselves in a mirror as they are cutting their hair. Hence, especially for the case of a user operating an automated hair cutting system to give themselves a haircut, it is important that the user be able to operate the automated hair cutting system in a simple and intuitive way. The present disclosure teaches techniques for how an automated hair cutting system may guide a user with audible sound, visual, haptic, and/or other signals for how to manipulate a hair cutting device. Coordinate axes that extend, e.g., vertically and horizontally through a user's head, and signals may direct a user to orient a hair cutting device relative to these axes during a haircut. Visual images on the screen of an electronic computing device may be provided in conjunction with audible sound signals, haptic signals, and other possible signals so that a user may respond to visual signals, sound signals, touch signals, indicator lights, other signals, or combinations of signals.

Hair cutting devices may include buttons, knobs, switches, touch sensitive areas, or other interfaces that may allow a user to send signals to an automated hair cutting system. Hair cutting devices may also include physical features, guides, shape, or other elements that a user may touch, and in touching them, may determine an orientation of the hair cutting device, so that the user may more easily manipulate the hair cutting device without needing visual confirmation.

Referring now to FIG. **1**, there is shown an embodiment of an automated hair cutting system **100** cutting a region of hair **110** on a user **102**. Automated hair cutting system **100** comprises a hair cutting device **120** including a cutter head **122**, an electronic computing device **108**, and a positioning device **104** having a plurality of positioning interfaces **106**. Hair cutting device **120**, electronic computing device **108**, and positioning device **104** may communicate and interact over wired or wireless electronic interfaces. Computing device **108** may include a user interface for receiving inputs from an operator.

Positioning signals may be generated and propagate between positioning interfaces **106** on positioning device **104** and sensors **123** on hair cutting device **120**. Positioning device **104** may be supported on the head of user **102** with ear supports **107** and head band **105**. Housings **118** may contain batteries, electronics, or other elements. Positioning device **104** utilizes a tubular construction, but those skilled in the art will recognize that many alternative structures and constructions for positioning devices may be used.

Analysis of these positioning signals may allow automated hair cutting system **100** to determine the position and/or orientation of hair cutting device **120** relative to the head of user **102**. Embodiments of automated hair cutting system **100** are described in more detail in Krenik '856. Hair cutting system **100** may operate through observation of and/or interaction with user **102** and/or positioning device **104** by hair cutting device **120** and/or other system elements to substantially allow the position and/or orientation of hair cutting device **120** to be determined relative to the head of user **102** so that selected regions of hair **110** may be collected in a cutter head **122** of hair cutting device **120**, extended to a desired length, and cut. Additional embodiments, modes of operation and additional description of automated hair cutting system **100** may be found in Krenik '856.

Some embodiments of automated hair cutting system **100** may not use a positioning device and the position and/or orientation of hair cutting device **120** relative to the head of user **102** may be determined through use of some combination of cameras, motion sensors, accelerometers, gyroscopes, and/or other sensors. Some embodiments of automated hair cutting system **100** may combine a positioning device **104** with a combination of cameras, motion sensors, accelerometers, gyroscopes, and/or other sensors for deter-

mination of the position and/or orientation of a hair cutting device **120** relative to the head of a user **102**.

Hair cutting device **120** is shown supported by hand **124** of an operator. The operator may be either user **102**, or another person giving user **102** a haircut. The operator may respond to instructions, queues, or additional guidance or information from electronic computing device **108** or other elements of automated hair cutting system **100** during a haircut. The instructions, queues, or additional guidance or information may be presented visually on a display of electronic computing device **108** or other electronic displays, and may include audible sound signals, indicator lights, haptic signals, or other possible signals. Hair cutting device **120** may also provide haptic signals to hand **124** in the form of vibrations, jarring, bumping, or jogging signals, or other forms of haptic signals. Some embodiments of automated hair cutting system **100** may include additional elements or additional features that attach to user **102**, are held by user **102**, interact with user **102**, provide guidance to user **102**, monitor user **102**, take images or video of user **102**, or otherwise function to observe, monitor, sense, signal, or guide user **102**. For example, a haptic device such as a vibrating watch band may be worn by user **102** on one of their wrists. Another example would be a positioning device **104** including an electronic display used to provide guidance or instructions to user **102**.

Electronic computing device **108** and other system elements of automated hair cutting system **100** may be connected with the internet, a wireless communication network, other computers, printers, information systems, or other systems. Automated hair cutting system **100** may collect and store information about user **102** including their age, sex, hair style, hair color, hair type, personal preferences, and other information and recommend hair care and other products for user **102** to purchase. In some embodiments, electronic computing device **108** may be configured such that user **102** can purchase one or more recommended products through an interface therethrough.

Certain embodiments may use positioning signals between the positioning interfaces **106** on positioning device **104** and sensors **123** on hair cutting device **120**. These signals may propagate from any of the positioning interfaces **106** to any of the sensors **123** on hair cutting device **120** and may comprise electromagnetic signals, sound signals, light signals, magnetic signals, acoustic signals, ultrasonic signals, infrared light signals, radar signals, sonar signals, lidar signals, or other types of signals. Some embodiments may be configured such that positioning signals propagate from a hair cutting device **120** to a positioning device **104**, or propagate in both directions. Positioning signals may be modulated to provide timing information or other information and may make use of FSK (Frequency Shift Keying), PSK (Phase Shift Keying), ASK (Amplitude Shift Keying), or other forms of signal modulation. Positioning signals may be processed using signal processing techniques including filtering, correlation, slicing, amplification, gain control, signal power level control, frequency detection, amplitude detection, phase detection, averaging, analog-to-digital conversion, decimation, interpolation, and/or other suitable signal processing techniques. Positioning signals from positioning interfaces **106** to sensors **123** may also be coordinated so that they do not interfere with each other, or only interfere in pre-defined ways that allow system operation. Those skilled in the art will recognize that positioning signals may be coordinated with TDMA (Time Division Multiple Access), FDMA (Frequency Division Multiple Access), CDMA (Code Division Multiple Access), or other suitable schemes for coordinating signals. Analysis of these positioning signals may be used in computation of the position and/or orientation of hair cutting device **120** relative to user **102**. Some embodiments may also comprise one or more cameras on hair cutting device **120**, positioning device **104**, electronic computing device **108**, or other system elements for collecting images or video of positioning device **104**, user **102**, or hair cutting device **120**, for analysis and use in computation of the position and/or orientation of hair cutting device **120** relative to user **102**. In Krenik '856, additional explanation is provided for a wide range of signal types, signal coding, signal modulation, signal coordination, and types of sensors or transducers that may be used to generate and/or sense these positioning signals, and many other aspects for various embodiments of signals, interfaces, cameras, sensors and other elements or signals for automated hair cutting system **100**.

Most hair cutting operations using automated hair cutting system **100** are intended for a user or operator to cut hair in a simple and effective manner. For example, a user **102** may start the automated hair cutting system **100** by switching on electronic computing device **108** and selecting a hair style. User **102** may then put on positioning device **104** and perform a calibration sequence to calibrate positioning device **104** to their head. In some embodiments, user **102** may use hair cutting device **120** to measure the length of their hair so that automated hair cutting system **100** can verify their hair is long enough for a given hair style (see Krenik '201 and Krenik '497 for more information on how hair length may be measured with a hair cutting device). With this completed, user **102** may simply begin collecting hair into cutter head **122** of hair cutting device **120** and extending hair for cutting. While user **102** is working, automated hair cutting system **100** may keep track of where hair may be left uncut and where errors in the orientation or position of hair cutting device **120** caused some hair to be cut too long. Automated hair cutting device **100** may also ensure that hair is never cut too short through analysis of the position and orientation of hair cutting device **120** and control of cutter head **122**. Clearly, if hair is cut somewhat too long due to how user **102** is manipulating hair cutting device **120**, due to rapid changes in the desired length of hair for a given style, or other reasons, hair may be cut again with a repeated cycle of collection, extension, and cutting of hair. And while user **102** is working to cut their hair, automated hair cutting system **100** may provide visual, audible, haptic, or other signals to user **102** to improve how they are manipulating hair cutting device **120**. Such guidance may be specific or may be more general. General advice, for example, may be suggestions such as "try to hold the handle a bit higher as you extend hair", "it may work better to collect hair on the side of your head with an upward combing motion", "move the cutting device a bit more slowly", and other possible suggestions. As user **102** completes working over their scalp and is completing a haircut, automated hair cutting system **100** may call user's **102** attention to areas of their scalp that may have been missed (i.e. where hair was left uncut) or where hair was cut too long due to errors in manipulating hair cutting device **120** (or due to limitations due to the size of cutter head **122** in areas where desired hair length changes rapidly, or due to other reasons). User **102** may decide to attend to these issues, or may decide that their hair looks good enough. For many users and for many hair styles, hair does not need to be cut to very high accuracy. Hence, many users may be happy enough with a haircut that includes small inaccuracies, but still looks acceptable. Some embodiments of automated hair

cutting system **100** may include haircut tolerance controls that allow a user **102** to control an accuracy tolerance to which hair may be cut and to ignore errors below a tolerance setting (in some embodiments, such accuracy tolerances may also be established automatically). Such tolerance controls may be accessed through electronic computing device **108** or possibly through other system elements that may be present in some embodiments.

Referring now to FIG. **2**, there is shown an embodiment of a cutter head **200** for use in hair cutting devices that allows hair to be collected, allows actuation of the cutter knives **204** in a first direction to apply pressure and friction to hair so that it may manipulated, extended, and cut, and may also enable cutting action when the cutter knives **204** are actuated in a second direction. Cutter head **200** comprises cutter knives **204**, comb teeth **202**, and body **220**. Cutter head **200** may be actuated in a variety of ways, including wherein cutter knives **204** are substantially above comb teeth **202** so that hair may be collected in cutter head **200**. Another actuation enables cutter knives **204** to move to the left (toward the lower left corner of FIG. **2**) so that rounded edges **208** of cutter knives **204** and comb teeth **202** apply pressure to hair collected in cutter head **200**. Applying pressure to hair collected into cutter head **200** creates friction which enables manipulation of hair collected in cutter head **200** with less possibility of the collected hair failing out of the cutter head **204**. Yet another actuation includes cutter knives **204** moving to the right (toward the upper right corner of FIG. **2**) so that sharp edges **206** of cutter knives **204** and comb teeth **202** meet and pass over each other to provide a cutting action. Left most comb tooth **203** and right most cutter knife **205** have only rounded edges **208** and have no sharp edges **206** as left most comb tooth **203** and right most cutter knife **205** are not used for cutting hair during a cutting stroke. Gap **242** and gap **244** provide spacing between cutter knives **204** and body **220** so that they may move to the right and left. Cutter head **200** may be fabricated from metals, ceramics, glass, sapphire, and other suitable materials.

In some embodiments, cutter knives **204** may be independently actuated so that hair collected between adjacent cutter knives **204** may be cut to different lengths; while in other embodiments cutter knives **204** may be actuated all together at the same time, or actuated in groups. Krenik '201 provides additional description of cutter heads similar to cutter head **200** and also describes additional embodiments of cutter heads suitable for some embodiments of hair cutting devices. While some embodiments may include teeth pointed in different directions, the examples provided in the present disclosure are similar to the teeth of cutter head **200**, which emanate in the direction away from the side of body **220** visible in FIG. **2**, are pointed away from body **220**, and are pointed substantially toward the lower right side of FIG. **2** in the view shown.

Referring now to FIG. **3**, there is shown an exploded view of a cutter head **300** that may be used in some embodiments of hair cutting devices. Cutter head **300** comprises a bottom comb **306** and a top cutter **304**. Bottom comb **306** comprises comb teeth **322** and tips **330**, and includes mounting standoffs **324** with mounting screws **328** for fastening the bottom comb **306** to a cutting device such as hair cutting device **120**. Top cutter **304** includes cutter knives **320**, and guide openings **318**. The mounting screws **328** may affix bottom comb **306** to a base of hair cutting device **120** and mounting standoffs **324** may engage guide openings **318** for maintaining a lateral force on top cutter **304** for guiding actuation of top cutter **304** relative to bottom comb **306**. The lateral force may come from a motor or actuator acting through a combination of levers, gears, hubs, or other elements. Other embodiments may use a wide range of couplings such as screws, welds, hubs, slots, or other couplings applied to couple motion from an actuator, motor, or associated levers, hubs, axles, or other mechanisms to top cutter **304**.

Cutter head **300** may be used in multiple ways to collect, extend, and/or cut hair during operation of automated hair cutting system **100**. For example, hair may be collected and extended through cutter head **300** when cutter knives **320** are substantially aligned on top of comb teeth **322** and hair collected in cutter head **300** may be cut when top cutter **304** is actuated so that the sharp edges of cutter knives **320** and comb teeth **322** meet and pass over each other. Cutter knives **320** and comb teeth **322** may be constructed similar to cutter knives **204** and comb teeth **202** of cutter head **200** or may be of other construction (see Krenik '201 for additional possible embodiments of cutter knives and comb teeth). It is noted, in particular, that the cutting edges of cutter knives **320** and comb teeth **322** as shown in FIG. **3** are substantially parallel. In the present disclosure, the benefits of cutter heads comprising cutter knives and comb teeth with slanted sharp edges will be subsequently described.

Base **332** of bottom comb **306** has a first thickness T1. In some embodiments, tips **330** will have a second thickness T2, smaller than the first thickness T1 of base **332**. Similarly, top cutter **304** and cutter knives **320** have a third thickness T3, and top tips **321** have a fourth thickness T4, which may likewise be smaller than third thickness T3. The smaller thickness T2 and T4 of tips **330** and top tips **321** relative to the thickness T1 and T3 of base **332** and cutter knives **320** enables cutter head **300** to pass through and separate hair with less resistance, similar to teeth of traditional hair combs.

In FIG. **4** there is shown a top view of another embodiment of a cutter head, cutter head **400**. Cutter head **400** comprises top cutter **402** and bottom comb **452**. Top cutter **402** comprises cutter knives **406** having slanted sharp edges **408**. Bottom comb **452** comprises left end comb tooth **462**, comb teeth **460**, and right end comb tooth **464**. Comb teeth **460** and right end comb tooth **464** have slanted sharp edges **466**. Bottom comb **452** comprises mounting standoffs **454** each having a hole **456** that may be used with a mounting screw. Top cutter **402** comprises guide openings **404** that mate with mounting standoffs **454** to provided guided motion of top cutter **402** relative to bottom comb **452**. Top cutter **402** may be driven by an actuator, motor, or other driver or mechanism. A driver, motor, actuator, or mechanism may be coupled to top cutter **402** by a wide range of couplings such as screws, welds, hubs, slots, or other couplings.

Cutter head **400** is similar in assembly and operation to cutter head **200** and cutter head **300** but with cutter knives and comb teeth having different shapes and constructions. Cutter head **400** includes slanted (top) sharp edges **408** and slanted (bottom) sharp edges **466** that meet and pass over each other to cut hair during a cutting stroke of cutter head **400** (similar to blades on a traditional pair of scissors). Openings **480** form between slanted sharp edges **408** and slanted sharp edges **466**, and hair may be collected in openings **480** when top cutter **402** is actuated to the left relative to bottom comb **452** (that is, top cutter **402** may be actuated toward the left side of FIG. **4** so that openings **480** are opened further). A cutting stroke of cutter head **400** occurs as top cutter **402** is actuated to the right (that is, toward the right side of FIG. **4**) so that slanted sharp edges **408** and slanted sharp edges **466** meet and pass over each

other, causing openings **480** to close and cut hair collected in them. As slanted sharp edges **408** and slanted sharp edges **466** meet and pass over each other, a cutting point **482** is formed in each opening **480** at the point where slanted sharp edges **408** and slanted sharp edges **466** meet. Cutting points **482** form first when slanted sharp edges **408** and slanted sharp edges **466** meet near base **470** during a cutting stroke of cutter head **400** and cutting points **482** move upwards (toward the top of FIG. **4**) as a cutting stroke of cutter head **400** progresses. During a cutting stroke, hair collected in openings **480** nearest the base **470** of cutter knives **406** is cut first and hair collected in openings **480** nearest the tips **472** of cutter knives **406** is cut last. The sides of cutter knives **406** opposite slanted sharp edges **408**, the sides of comb teeth **460** opposite slanted sharp edges **466**, and the right side of left end comb tooth **462** may be used to apply pressure and friction to hair collected in cutter head **400** (similar to description related to cutter head **200**). Krenik '201 provides additional embodiments and descriptions of cutter heads similar to cutter head **400** and other possible cutter heads.

FIGS. **6** and **7** illustrate embodiments and methods related to control and utilization of slanted sharp edges of cutter knives and comb teeth that may meet and cut hair at different times during a cutting stroke. While cutter head **400** comprises slanted cutting edges for both slanted sharp edges **408** on cutter knives **406** and slanted sharp edges **466** on comb teeth **460** and right end comb tooth **464**, those skilled in the art will recognize that embodiments with a combination of parallel and slanted sharp edges are possible. For example, if slanted sharp edges **466** on comb teeth **460** and right end comb tooth **464** are replaced with sharp edges that are substantially parallel to the outer edges of left end comb tooth **462** and right end comb tooth **464**, the presence of slanted sharp edges **408** on cutter knives **406** still enable hair to be collected and cut accordingly. Similarly, some embodiments may comprise parallel sharp edges on cutter knives and slanted sharp edges on comb teeth. Those skilled in the art will recognize that in addition to cutting edges that are substantially straight and slanted, some embodiments of cutter heads may utilize cutting edges that incorporate various curved edges, such as convex edges, concave edges, a combination of curves, a combination of curved and straight edges, or other shapes. Cutter heads with curved cutting edges may also be applied. Many embodiments of cutter heads incorporating cutter knives with slanted edges at various angles, curved edges, parallel edges, serrated edges, wavy edges, combinations of different shapes of edges, and other suitable shapes or types of edges are possible.

Referring now to FIG. **5**, there is shown a side view of a cutter head **500** trimming long hair **524** to create short hair **526** on the back of a neck **522**. Cutter head **500** comprises top cutter **504** and bottom comb **506**. Cutter head **500** may be of similar construction to cutter head **200**, cutter head **300**, cutter head **400**, or other possible embodiments of cutter heads. Cutter head **500** has comb teeth that are thinner near the tips **508** of the comb teeth of bottom comb **506**, similar to cutter head **300**. Cutter head **500** is shown engaging long hair **524** near the tips **508** of top cutter **504** and bottom comb **506** so that long hair **524** may be cut to a shortest possible length. In some hair styles, hair may be cut as short as possible on some regions of the scalp. For example, many common men's hair styles involve shaving or trimming the back of the neck so that hair on the back of a man's neck but below a scalp line is neatly kept very short. And some modern hair styles include shaved hair or hair cut rather short on some regions of the scalp. Using cutter head **500** to cut hair at the tips **508** of the cutter knives and comb teeth, where the comb teeth are the thinnest, allows hair to be cut to a substantially short length on desired regions of a user's **102** scalp, including on neck **522**. Cutter head **500** may be actuated continuously so that hair is cut as it enters cutter head **500**.

Automated hair cutting system **100** may use the position and/or orientation of a hair cutting device to which cutter head **500** is attached to control actuation of cutter head **500** to achieve various hair lengths. For example, when cutter head **500** is positioned near the back of neck **522**, automated hair cutting system **100** may actuate cutter head **500** in a continuous fashion to cut hair short. As cutter head **500** moves upwards away from the back of neck **522**, actuation may continue to cut long hair **524** to produce short hair **526**. As tip **508** of cutter head **500** reaches the point where longer hair is desired, actuation of cutter head **500** may be stopped or paused in order to prevent hair from being cut short than desired for a certain region on user's **102** head. In some areas of neck **522**, longer hair may be desired than the length of short hair **526**, so hair is collected in cutter head **500**, extended away from neck **522**, and cut to a desired length. As the operator moves cutter head **500** upward over the back of their neck, automated hair cutting system **100** may also provide guidance to user **102** on how best to orient cutter head **500** and possibly also how best to orient their head and neck. Such guidance may be provided visually on the display screen of electronic computing device **108**, may include audible instructions produced by a speaker in electronic computing device **108**, may be signaled to user **102** through haptic signals delivered through hair cutting device **120** that cutter head **500** is attached to, may be provided to user **102** through indicator lights on a hair cutting device **120**, or may be provided in other possible ways or combinations of ways from the various elements possible for various embodiments of automated hair cutting system **100**. Guidance may include instructions to begin moving cutter head **500** forward, stop moving cutter head **500** forward, slow the rate of movement of cutter head **500**, turn cutter head **500** clockwise or counter-clockwise so that the tip **508** of cutter head **500** meets the points along which cutting action will be stopped (for a more accurate interface between where longer hair will meet short hair for a given hair style), rock hair cutting device **120** forwards or backwards so that the tip **508** of cutter head **500** engages hair and slides along neck **522**, bending the neck of user **102** to beneficially align skin and hair to the position and/or motion of cutter head **500**, or other possible signals and guidance that may help user **102** achieve results.

Bottom comb **506** of cutter head may be able to better cut hair to a substantially short length with comb teeth that are thinner near their tips. The cutting edges of top cutter **504** and bottom comb **506** may be slanted similarly to the slanted sharp edges **408** and slanted sharp edges **466** as shown on cutter head **400** in FIG. **4**. Cutter head **300** as shown in FIG. **3** with cutting edges that are substantially parallel may also be used to cut hair to substantially short lengths as shown in FIG. **5**. Operation of cutting hair to a substantially short length as shown in FIG. **5** may be achieved with a wide range of cutter heads with various combinations of slanted, curved, parallel, contoured, or otherwise shaped cutting edges.

FIG. **6** illustrates one embodiment of a cutter head **600** and a method for cutting hair wherein actuation of a cutting stroke of cutter head **600** is coordinated in time with extension of hair through the cutter head **600** as a hair cutting device is lifted away from scalp **604**. (FIG. **6**

illustrates the scalp **604** from a side view.) Scalp **604** is shown along with long hair **614**, cut hair **612**, desired hair length guide line **616**, cutter head **600**, and cutter head cutting interface guide line **620**. Long hair **614** (that may not yet be cut to a desired length), and cut hair **612** is shown extending horizontally to the left from scalp **604**, but may be cut in various other orientations. Hair may be cut through movement of cutter head **600** to extend hair along with coordinated control of the actuation of cutter head **600** to cut hair. Cutter head **600** may be of similar construction and may comprise similar features to cutter heads **200** and **400**. Cutter head **600** includes slanted cutting edges, similar to slanted sharp edges **408** of cutter knives **406** and slanted sharp edges **466** of comb teeth **460** and right end comb tooth **464** as were shown for cutter head **400**. That is, as the cutter knives **624** and comb teeth **626** of cutter head **600** meet and pass over each other during a cutting stroke, hair near the base **628** of cutter knives **624** will be cut in the earlier part of the cutting stroke and hair near the tips **630** of cutter knives **624** will be cut in the later part of the cutting stroke. The base **628** and tips **630** of cutter knives **624** correspond in similar fashion to the base **470** and tips **472** of cutter knives **406** as shown in FIG. **4**.

During a haircut using automated hair cutting system **100**, cutting device **120**, and cutter head **600**, a portion of long hair **614** may be collected into cutter head **600** through a combing action of cutter head **600** near the scalp **604** so that the location of the collected long hair **614** on scalp **604** is known and a desired length for it may be established based on a desired hair style. For example, desired hair length guide line **616** provides a contour to which long hair **614** is desired to be cut. Hence, once long hair **614** has been collected in cutter head **600**, an operator may begin extending cutter head **600** away from scalp **604** to extend the collected long hair **614** in cutter head **600** for cutting.

Various embodiments of automated hair cutting system **100** may begin the extension of hair for cutting in various ways. Some embodiments may detect when hair has been collected into cutter head **600** and may provide the operator with signals as discussed hereinabove (including visual, audible, haptic, or through any other possible signaling techniques) that hair has been successfully collected in cutter head **600** and extension of hair for cutting may begin. Other embodiments or modes of operation may include the operator signaling the automated hair cutting system **100** that hair has been collected in cutter head **600** and that extension of hair for cutting may begin. In some embodiments, even though the operator has lifted hair cutting device **120** away from scalp **604**, automated hair cutting system **100** may need this signal from the operator to know a location from which to reference measurements for how long hair is being extended so that it may automatically begin a cutting stroke of cutter head **600**. The operator may signal by pressing a button, switch, touch sensitive display, or other input device (that may be on electronic computing device **108**, hair cutting device **120**, or other system element); by providing a verbal signal that may be received and processed by electronic computing device **108**, hair cutting device **120**, or other system element; by nudging or bumping hair cutting device **120** in a pre-defined manner (such as momentarily pressing cutter head **600** against scalp **604**); or by other possible ways of signaling that hair has been collected in cutter head **600** and that extension of hair for cutting may begin. Some embodiments of cutter head **600** may include a touch sensor that may sense when cutter head **600** has contacted the scalp **604** of user **102**. (See Krenik '856 for more description on touch sensors which may be used with the present disclosure.) Some embodiments of touch sensors may additionally measure the distance from cutter head **600** to scalp **604** and some embodiments of touch sensors may also provide information on the level of resilience, compliance, softness, springiness, or other aspects of scalp **604**.

As long hair **614** collected in cutter head **600** is extended for cutting, the orientation of cutter head cutting interface guide line **620** relative to desired hair length guide line **616** near cutter head **600** is important. Desired hair length guide line **616** provides the desired length for hair collected in cutter head **600** to be cut. Cutter head cutting interface guide line **620** lies at the interface of cutter knives **624** and comb teeth **626** of cutter head **600** and provides the line along which hair collected in cutter head **600** will be cut if cutter head **600** is rapidly actuated on a cutting stroke. As collected long hair **614** is extended through cutter head **600** as cutter head **600** is lifted away from scalp **604**, an intersection point **632** of desired hair length guide line **616** and cutter head cutting interface guide line **620** will progress along cutter head cutting interface guide line **620** and will reach base **628** of cutter knives **624**; and, as this occurs, if actuation of a cutting stroke of cutter head **600** is coordinated in time with the extension of hair through cutter head **600** so that the slanted cutting edges of cutter knives **624** and comb teeth **626** meet and begin to pass over each other so that hair near base **628** of cutter knives **624** begins to be cut, then the long hair **614** collected in cutter head **600** near base **628** will be cut. As cutter head **600** is further lifted away from scalp **604** and intersection point **632** further progresses to tip **630** of cutter knives **624**, further coordinated actuation of the cutting stroke of cutter knives **624** relative to comb teeth **626** may also progress so that substantially all long hair **614** collected in cutter head **600** is cut substantially to its desired length. Hence, cutter heads **600** with slanted cutting edges may be actuated for cutting in coordination with movement of the cutter head **600** so that as portions of hair collected in cutter head **600** are extended and reach their desired length; that the cutting stroke is so coordinated that those portions of hair are cut substantially to their desired length.

Maintaining the cutter head **600** along desired hair length guide line **616** and cutter head cutting interface guide line **620** enables the collected hair to be cut according to a desired length, programmed into a user interface of automated hair cutting system **100**, such that actuation of cutter head **600** is timed accordingly with the extension of hair collected therein. If cutter head **600** is rotated counterclockwise so that intersection point **632** is above tip **630** (that is, above it in the view as shown in FIG. **6**) before hair collected in cutter head **600** reaches a length suitable for actuation of a cutting stroke, then the cutting stroke cannot actuate and hair cannot be cut as desired. For the cutting action to be coordinated accordingly with hair extension, intersection point **632** will be positioned beneath base **628** of cutter knives **624** before the long hair **614** collected in cutter head **600** is extended to its desired length for cutting. If cutter head **600** is oriented improperly (so that the hair collected in cutter head **600** does not first reach its desired length at base **628** and progresses instead so that the collected hair reaches its desired length first at the tip **630**) then cutter head **600** actuation cannot begin. Automated hair cutting system **100** may signal cutter head **600** and prevent actuation thereof to prevent hair from being cut to an undesired length. Similarly, cutter head may be configured to receive instructions for actuation so that no hair is cut shorter than its desired length and automated hair cutting system **100** may signal to user **102** (through any possible

visual, audible, haptic, or other suitable signal) that a sub-optimal cut has occurred. Alternatively, automated hair cutting system **100** may not actuate cutter head **600** at all (so that user **102** realizes an error occurred, or automated hair cutting system **100** may additionally send a visual, audible, haptic or other signal to user **102** to mark the occurrence of the error). In any case, user **102** may then try again to collect long hair **614** in cutter head **600** and attempt a new extension of cutter head **600** away from scalp **604** for cutting hair in an optimal fashion (and potentially improving the orientation of cutter head **600** as it is extended away from scalp **604** so that optimal results are possible).

Some embodiments of automated hair cutting systems may guide user **102** so that as cutter head **600** is extended from scalp **604** to extend collected hair for cutting, the orientation of cutter head **600** allows coordination of a cutting stroke of cutter head **600** with extension of cutter head **600** away from scalp **604** so that optimized hair cutting may take place. While the view shown in FIG. **6** has intersection point **632** below base **628** of cutter knives **624** so that optimal cutting may take place, an operator would need only to alter the orientation of cutter head **600** somewhat to enable optimized cutting if cutter head **600** was initially oriented incorrectly. Embodiments of automated hair cutting system **100** may provide visual, audible, haptic, or other suitable signals to an operator of a hair cutting device **120** to position and move hair cutting device **120** as it is lifted away from scalp **604** so that extension of hair and actuation of cutter head **600** may be coordinated so that hair collected in cutter head **600** may be substantially optimally cut. That is, an operator may be directed to rotate the handle of a hair cutting device **120**, including cutter head **600**, forward in the direction that the teeth of cutter head **600** are pointing, or rearward in the direction opposite that the teeth of cutter head **600** are pointing. Hair cutting device **120** need not be precisely oriented for such optimal cutting to be achieved. Cutter head **600** may be rotated in various directions, including clockwise at varying angles during a hair cutting process. Actuation of cutter head **600** may still be coordinated with extension of cutter head **600** over some range of orientation of cutter head **600**, so the operator need only orient hair cutting device **120** sufficiently within a defined range. If cutter head **600** is rotated clockwise to the point that the teeth of cutter head **600** nearly point directly toward scalp **604**, coordinated cutting action of cutter head **600** may still occur; however, collection of hair into cutter head **600** may be difficult, and only small amounts of hair may be collected and extended at a time. Accordingly, embodiments of automated hair cutting system **100** may generally guide operator to orient cutter head **600** over a more limited range of orientation.

Hair cutting device **120** may include a substantially long and straight handle for better orienting cutter head **600** than using a shorter handle. Some embodiments of hair cutting devices may have handles that include a reference feature, handle shape, textured grip, or other feature so that an operator may know the direction that the teeth of cutter head **600** are pointing without having to look at hair cutting device **120**, such as on hair cutting device **900** shown in FIG. **9**.

Various factors may be included in determining cutter head **600** orientation. For example, desired hair length guide line **616** may be a contour line for certain hair styles. Accordingly, coordinating actuation of cutter head with hair collection and extension may include coordinating the time and speed with which cutter head **600** is actuated relative to the speed at which cutter head **600** is being lifted away from scalp **604**, and may include configuring a variable actuation speed. Certain factors may need to be maintained to achieve a desired hair style and length, including the speed at which cutter head **600** is lifted away from scalp **604**, the speed and accuracy to which cutter head **600** may be actuated through a cutting stroke, the actual shape of the slanted cutting edges used in cutter head **600**, the amount of hair collected in cutter head **600**, the level of force required on cutter head **600** to actuate it through a cutting stroke, and other factors. For some embodiments, the operator may be directed to not only alter the orientation of cutter head **600** as it is extended from scalp **604**, but to also alter the speed or position of cutter head **600** so that the ability to optimally cut hair is enabled.

Some embodiments of cutter heads may allow independent actuation of cutter knives so that hair may be more optimally cut across the cutting surface of cutter head **600** if cutter head **600** is not optimally oriented, and some embodiments may be configured to disable actuation of cutter head **600** if orientation is not within a desired range. For cutter heads where all cutter knives are actuated together, actuating cutter knives with slanted cutting edges in coordination with controlled orientation and extension of cutter head **600** more optimally cuts hair than would otherwise be possible and relaxes the need for a user **102** to precisely orient cutter head **600**. Some embodiments of cutter heads **600** may actuate all cutter knives at once such that all the hair collected in such a cutter head **600** may be cut at once. Some hair styles may require hair to be cut at substantially different lengths over even a relatively small area of scalp **604**. And some regions of scalp **604**, may be sharply curved (such as where the sides of a user's **102** head curve to form the top of their head, or in other possible regions). As a result, actuation of a cutter head **600** for a cutting stroke, even if the cutting stroke is actuated in coordination with the extension of cutter head **600** may leave some hair inaccurately cut. Some embodiments of automated hair cutting system **100** may compute the length that all hair is being cut to and ensure that cutter head **600** is actuated to ensure none of the hair collected in cutter head **600** is cut too short. That is, actuation of cutter head **600** may be controlled so that as cutter head **600** is lifted away from scalp **604** to extend hair for cutting that hair collected in cutter head **600** is substantially all cut either accurately or somewhat longer than is desired. Automated hair cutting system **100** may keep track of where hair was cut somewhat longer than desired and alert an operator that additional cycles of collecting, extending, and cutting such longer than desired hair is needed to achieve acceptable tolerances for cut hair.

Some hair styles involve creating randomized, feathered, or other features in hair. The embodiment shown in FIG. **6** may allow such features to be included if cutter head **600** is actuated in a somewhat randomized fashion. That is, as the cutter knives **624** and comb teeth **626** of cutter head **600** are actuated to cut hair, some level of reciprocal motion, jittering, dithering, or otherwise randomizing of the motion of cutter knives **624** may be applied so that the resulting cut hair incorporates some randomness or pattern to its length. Cut hair **612** is shown in FIG. **6** as uniformly cut to the length of desired hair length guide line **616**. However, if cut hair **612** were cut with patterned or randomized partial actuations of cutter head **600**, some of the hairs of cut hair **612** may be slightly longer and others slightly shorter than desired hair length guide line **616**. Orientation of cutter head **600**, speed of extension, speed and amplitude of actuation, speed and amplitude at which cutter head **600** is actuated reciprocally, and actuation patterns may vary according to hair type and desired style. Different types (straight, curly,

etc.), weights (heavy/thick or light/thin), colors (blond, brunette, etc.), shine levels (shiny, dull, etc.), lengths (long, short, etc.), styles, and other factors associated with a user's **102** hair may have impact on which approaches to randomizing or feathering hair may be most desirable. Although some embodiments may comprise teeth in the cutter head **600** extending substantially orthogonal to the main axis and handle of a hair cutting device **120**, some embodiments may comprise a smaller angle than 90 degrees such that an operator may hold hair cutting device **120** in a relatively natural and ergonomic position.

Some embodiments of hair cutting devices **120** may include mounts having controls for cutter head **600**, such that the mounts receive instructions or signals from the electronic computing device **108** or other elements of an automated hair cutting system **100** to change the orientation of cutter head **600**. Accordingly, the received signals or instructions may also begin actuation of cutter head **600** such that cutting the hair is coordinated in time with extension of hair through cutter head **600**. Such automatic adjustment of the orientation of cutter head **600** may be done with electric actuators, hydraulic actuators, pneumatic actuators, or other suitable actuation techniques and may be controlled electronically based on information received from automated hair cutting system **100** regarding the orientation of a hair cutting device **120** relative to the head of a user **102**. Some embodiments of hair cutting devices that automatically adjust the orientation of their cutter heads may alter the orientation of their cutter head in two or more directions so that both orientation along the length of the teeth of cutter head **600** (as shown in the side view shown in FIG. **6**) and across the width of cutter head **600**, may be done automatically so that the full cutting surface of cutter head **600** is more optimally oriented for various hair cutting operations. Those skilled in the art will recognize that automatic controls for the orientation of cutter heads may be combined with appropriate compensations to computations for the length of extended hair so that it may be substantially optimally cut.

FIG. **7** shows a side view of a side or back of a scalp **704**. Scalp **704** includes cut hair **712**, uncut hair **710**, and parted hair **714** as shown. Parted hair **714** has been cut to a similar length to cut hair **712**, but has been combed or manipulated to create part **716**. Cutter head **700** is shown in FIG. **7** and may be similar in construction and have similar features as cutter head **600** and cutter head **400**. Tip **708** of cutter head **700** is shown partially inserted into cut hair **712** so that cutter head **700** may be partially actuated to cut some, but not all, of the hair collected in cutter head **700**. In this way, cut hair **712** may be thinned. Thinning hair is a common hair styling technique and may be used to reduce the thickness of hair and provide various tapered effects in some hairstyles. The location at which part **716** is formed, the distance into which tip **708** is inserted into cut hair **712**, whether hair is thinned near scalp **704** or whether it is thinned after cutter head **700** has been extended away from scalp **704**, and the amount to which cutter head **700** is actuated to partially cut collected hair will factor in to desired results. Automated hair cutting system **100** may recommend where and how hair may be thinned and may also allow user **102** to thin hair as they desire to provide a customized style. For example, automated hair cutting system **100** may stop all actuation of cutter head **700** and allow user **102** to use cutter head **700** as a comb (with cutter knives substantially positioned on top of comb teeth so that hair may flow smoothly through cutter head **700**), and utilize the positioning and orientation measuring capability of automated hair cutting system **100** to help user locate part **716** in a desirable place on their scalp. Automated hair cutting system may then direct user for how far to insert tip **708** into cut hair **712** and signal to user when tip **708** is properly inserted into cut hair **712**. Automated hair cutting system may then thin hair at user's **102** scalp **704** while cutter head **700** is substantially stationary, or may direct the operator to lift cutter head **700** away from their scalp **704** so that thinning may take place along the length of cut hair **712** (possibly at several locations or even distributed substantially continuously along the length of cut hair **712**). Once hair has been thinned above part **716**, automated hair cutting system **100** may direct the operator to form a new part an appropriate distance above part **716** so that an additional cycle of hair collection and thinning may occur. Alternatively, the operator may form a part **716** with a comb or other tool for manipulating hair at a desired location on their scalp and may insert tip **708** into part **716** (with tip **708** at the parting line between parted hair **714** and cut hair **712**) so that automated hair cutting system **100** may determine the location of part **716** on scalp **704**. User **102** or the operator may then input into a user interface the amount of their hair to be thinned and whether it is to be thinned at the scalp, tapered along the full length, or otherwise thinned in another desired way (for example, user **102** may want 10% of their hair to be thinned out at the scalp). Automated hair cutting system **100** may then direct the operator to insert tip **708** a correct amount into cut hair **712** and undertake the desired thinning operation.

FIG. **8** shows user **102** wearing positioning device **104** in conjunction with hair cutting device **120**. FIG. **8** includes imaginary horizontal axis **804** extending from the back center of user's **102** head forward through user's **102** nose and pointed forward in the direction user **102** would look straight forward; and imaginary vertical axis **802** extending vertically through the center of user's **102** head and pointing directly upwards. Circle **810** surrounds user **102** and intersects imaginary horizontal axis **804** both in front of and behind user's **102** head. Circle **814** encircles user's **804** head and the handle of hair cutting device **120**. Circle **810** and circle **814** may be used to define lines of latitude (i.e. parallels as are used on a common earth globe) around user's **102** head. Half-circle **812** as shown in FIG. **8** intersects circle **810**, circle **814**, the handle of hair cutting device **120**, and imaginary vertical axis **802** above user's **102** head. Half-circle **812** loops over the top of user's **102** head and may be used to define a line of longitude (i.e. a meridian as are used on a common earth globe) around user's **102** head. Additional circles or half-circles extending over user's **102** head and through imaginary vertical axis **802** may be used to define additional lines of longitude (i.e. meridians).

As noted above with regard to FIGS. **5-7**, many hair cutting operations involve collecting hair in a cutter head, such as cutter head **122** of hair cutting device **120** as shown in FIG. **8**, and extending hair for cutting (or thinning, tapering, or other hair cutting operations). During a hair cutting operation, an operator may need to collect hair from specific areas of the head and move hair cutting device **120** within a range of positions and a range of orientations to cut hair. Accordingly, automated hair cutting system **100** may send signals for positioning and orienting hair cutting device **120**. For the embodiment shown in FIG. **8** only two axes, imaginary horizontal axis **804** and imaginary vertical axis **802** are used to provide a simple and intuitive system so that simple signals and instructions to an operator, such as user **102**, may be easily interpreted. For example, if the operator is holding and manipulating hair cutting device **120**, but the orientation of hair cutting device **120** is incorrect, a simple

audible command of "UP" delivered from electronic computing device **108** may direct the operator to rotate the handle of hair cutting device **120** upwards along meridian arc **806** toward the top center of their head. A simple audible command of "FORWARD" may direct the operator to rotate the handle of hair cutting device **120** forward toward the nose in a direction similar to parallel arc **808**. Note that parallel arc **808** lies on circle **814** and meridian arc **806** lies on half-circle **812**. Visual signals may also be used by automated hair cutting system **100** and, as an example, an image similar to that provided in FIG. **8** may be displayed on electronic computing device **108** with the direction to rotate the handle of hair cutting device **120** along parallel arc **808** and meridian arc **806** highlighted with bring colors, flashing lights, or other indicators to make the desired directions of rotation of the handle of hair cutting device **120** clear. Instead of audible verbal commands such as "UP" and "FORWARD", some embodiments of automated hair cutting system **100** may make use of audible signals using variable volume, pitch, or other variable patterns to indicate how a user **102** may manipulate hair cutting device **120**. For example, a chime signal may change pitch and send a higher pitched signal to indicate to user **102** to rotate hair cutting device **120** upwards along meridian arc **806** and a lower pitched signal to indicate to user **102** to rotate hair cutting device **120** away from the top of their head. The chime signal may get louder to indicate to user **102** to rotate hair cutting device **120** forward toward their nose along parallel arc **808** and softer to indicate to user **102** to rotate hair cutting device **120** toward the back of their head along parallel arc **808**. Haptic signals may also be used with vibration amplitudes, frequencies, and patterns of hair cutting device **120** providing signals felt by user **102** as they manipulate hair cutting device **120** to indicate directions for how hair cutting device **120** may be rotated. Those skilled in the art will recognize that a very broad range of audible signals, visual signals, haptic signals, and other possible signals may be used, and may also be used in conjunction with other signals or instructions according to the preferences input by the operator.

While FIG. **8** uses an axis system, some embodiments of automated hair cutting system **100** may provide signals to a user **102** for how to position or orient a hair cutting device **100** with no reference at all to imaginary axes or other orientation references, such as positioning ranges, and other positioning methods discussed herein. For example, if the operator feels a mild haptic vibration signal from hair cutting device **120**, it may mean that the orientation of hair cutting device **120** needs to be corrected. The operator may have reason to believe that they are holding the handle of hair cutting device **120** too high (too near the top center of their head) and may lower the handle in an attempt to correct the situation. If the haptic vibration signal from hair cutting device **120** reduces in strength, this may signal that cutting device **120** is moving in a direction that is closer to the desired orientation. Signaling, such as haptic vibration may change according to the movement of hair cutting device **120**, indicating to the operator whether the hair cutting device is being moved correctly according to the desired result. In some embodiments, detailed information may be provided on the display screen of electronic computing device **108** while signals, such as haptic signals are used to guide the operator, so that if the operator is not clear on which direction to rotate the handle of hair cutting device **120**, that they may look to electronic computing device **108** for visual (and also possibly audio) information and guidance.

In addition to providing direction to a user **102** or operator for how to orient hair cutting device **120**, signals may be provided for where to collect hair. These signals may be additional signals to those used to provide directions regarding the orientation of hair cutting device **120**, or may be the same or similar signals to those used to provide directions on orienting hair cutting device **120**. In the case that the same or similar signals are used, electronic computing device **108** or other elements providing signals and guidance may be used to direct whether orientation or position for collection of hair is being directed at a given time. And automated hair cutting system **100** may also provide direction to user on how hair cutting device **120** may be rotated so that the teeth of hair cutting device **120** point in a favorable direction. Audible, visual, haptic, or other signals may be used to convey appropriate directions for all aspects for the location and orientation of hair cutting device **120**.

FIG. **9** shows an embodiment of a hair cutting device **900**. Hair cutting device **900** comprises a handle **902** having a center body **904**, a distal center body **936** with a cutter head **922** coupled thereto and an end button **912** and main button **913** at a proximal end thereof. The center body **904** comprises a plurality of sensors **908** coupled to the center body **904** via a plurality of mounting posts **906**. Cutter head **922** is mounted on cutter head base **932** at the distal end of the distal center body **936** with relief areas **934** on either side thereof. Relief areas **934** provide openings around cutter head **922** for manipulation around ears and other facial features. Sensors **908** are similar in construction and function to sensors **123** of FIG. **1**. While a user **102** may access electronic computing device **108** to provide input and receive signals, a user **102** may be engaged in cutting their hair and observing themselves in a mirror; and looking to electronic computing device **108** may be distracting. Accordingly, some embodiments of hair cutting devices may include buttons, switches, touch interfaces, electrical control knobs, or other features that allow a user **102** to interface with automated hair cutting system **100**. Main button **913** and end button **912** may be configured to send one or more signals to a user interface of automated hair cutting system **100**, regardless of which is pressed, so that user **102** may access whichever of the buttons is most convenient for them to reach based on how hair cutting device **900** is being manipulated at a given time. For other hair cutting operations, or in other embodiments, main button **913** and end button **912** may serve different purposes. For example, end button **912** may be used for signals from user **102** related to operation of hair cutting device **900** and automated hair cutting system **100**, while main button **913** is reserved and always serves as a safety stop button, wherein main button **913** would be configured to stop action of cutter head **922** immediately when pressed.

In other embodiments, main button **913** and/or end button **912** may serve different purposes at different times during a haircut. For example, main button **913** may be used at some times to indicate that hair is collected in cutter head **922** and extension of hair for cutting may commence; but an additional press of main button **913** at this point may signal that cutter head **922** is to be disabled and cutter knives returned to a rest position above comb teeth (so that cutter head **922** may be easily removed from a user's **102** hair). In yet another embodiment, pressing and holding main button **913** in a depressed position may indicate that hair is collected in cutter head **922** and extension of hair for cutting may commence; and a release of main button **913** may indicate that cutter head **922** is to be disabled (that is, cutter head **922** may only be actuated for cutting while main button **913**

remains depressed for such an embodiment). Some embodiments may further include an indicator light (or lights) on hair cutting device **900** and such lights may be configured to be visible when viewed in a mirror, wherein the light(s) indicate various signals while operating the automated hair cutting system **100**. A variety of shapes, sizes, and placements of buttons, switches, knobs, touch sensitive surfaces, and other user input devices may be used for signaling and controlled hair cutting device **900** or automated hair cutting system **100**.

Handle **902** of hair cutting device **900** includes ridge **903**. Ridge **903** comprises an elevated ridge along a portion of handle **902** in the direction that the teeth of cutter head **922** point. As a user **102** operating automated hair cutting system **100** may primarily concentrate on their face and hair as they look into a mirror as they cut their hair, user **102** can better determine the direction cutter head **922** teeth are pointing without having to look at hair cutting device **900** by feeling ridge **903**. Ridge **903** on handle **902** provides user **102** with a reference of the orientation of hair cutting device **900** (and accordingly, the direction the teeth of cutter head **922** point) while holding hair cutting device **900**. As hair cutting device **900** is manipulated about the head of a user **102** during a haircut, ridge **903** may provide an orientation reference for user **102** by feeling the location of ridge **903**. Ridge **903** may be formed from metals, wood, plastics, or other materials and may be formed with handle **902** or may be formed separately and then affixed to handle **902**. Other orientation references such as variations in the shape, texture, and size of handle **902** and ridge **903** may be used.

A cutter head of a hair cutting device may be tilted so that the cutter head tips slide over a scalp while the cutter head is actuated so that a closer cutting or shaving action than may otherwise be possible is achieved. The operator may be guided to orient a hair cutting device so that hair collected near the base region of a cutter head (near where the cutter knives and comb teeth first meet when the cutter head is actuated to cut hair) may be cut first and hair near the tips of the cutter head may be cut later, so that hair is cut substantially accurately as the hair cutting device is manipulated to extend hair for cutting. The tips of a cutter head may be inserted into hair, possibly along a part that has been combed into the hair, so that thinning, feathering, layering, or other such desired effects maybe produced.

Operation of an automated hair cutting system may involve an operator interacting with an electronic computing device, a positioning device, a hair cutting device, and possibly with other elements that may be present in some embodiments of automated hair cutting systems. Some users of automated hair cutting systems may prefer to observe themselves in a mirror as they are cutting their hair. Especially for an operator giving themselves a haircut, it is important to be able to operate the automated hair cutting system in a simple and intuitive way. An automated hair cutting system may guide the operator with sound, visual, haptic, and other forms of signals to guide the user to manipulate a hair cutting device. Imaginary coordinate axes may be introduced that extend vertically and horizontally through the haircut recipient's head (or in other locations or directions), and sound signals or other signals may direct a user to orient a hair cutting device relative to these axes during providing a haircut. Visual images on the screen of an electronic computing device may be provided in conjunction with audible sound signals, haptic signals, or other signals so that a user may respond both to a visual image and to sound signals, haptic signals, other signals, or combinations of signals. Buttons, knobs, touch sensitive areas, switches and other interfaces allowing the operator to send signals to an automated hair cutting system may be provided on a hair cutting device. A ridge, groove, or other physical feature may be added to a hair cutting device so that the operator may determine the direction the teeth of a cutter head are pointing based on touching the hair cutting device.

Those skilled in the art to which the present disclosure relates will appreciate that other and further additions, deletions, substitutions and modifications may be made to the described embodiments.

The invention claimed is:

**1**. A cutting device for use with an automated hair cutting system, comprising:

a handle having a proximal and distal end;

a cutting head positioned near the distal end of the handle, the cutting head comprising:

a cutting instrument, said cutting instrument having a plurality of cutter knives, said cutter knives configured having:

a first surface extending to a second surface and forming a sharp edge therebetween; and

a contoured surface extending from the second surface to the first surface; and

a comb coupled proximate the cutting instrument, said comb having a first and second end and a plurality of teeth positioned therebetween,

wherein the plurality of teeth and at least one of the first and second end have:

a first surface extending to a second surface and forming a sharp edge therebetween; and

a contoured surface extending from the second linear surface to the first surface;

wherein the sharp edges of the cutter knives are configured to slidingly engage the sharp edges of the plurality of teeth when the cutting instrument is actuated; and

at least one positioning sensor secured to the cutting device and configured to interact with a positioning device that is configured to be secured to a head of a user and having a positioning interface, said interaction comprising at least one signal indicating the position of the cutting head relative to the positioning interface.

**2**. The cutting device according to claim **1**, further comprising at least one button, said at least one button configured to receive input from an operator of the cutting device.

**3**. The cutting device according to claim **2**, wherein the at least one button is configured to initiate a signal that hair is collected in said cutter head when said at least one button is depressed and to immediately stop actuation of said cutting instrument when said at least one button is released.

**4**. The cutting device according to claim **1**, wherein the handle comprises at least one positioning guidance ridge extending between the distal and proximal ends.

**5**. The cutting device according to claim **1**, wherein said automated hair cutting system further comprises a computing device comprising a user interface configured to receive inputs from an operator of the cutting device.

**6**. The cutting device according to claim **5**, wherein the computing device is configured to receive the at least one signal indicating the position of the cutting head relative to a surface having hair extending therefrom and prepare instructions for an operator using the cutting device.

**7**. The cutting device according to claim **6**, wherein the instructions indicate one or more movements of the cutting device for cutting hair to a specified length.

**8**. The cutting device according to claim **6**, wherein the instructions indicate a time to actuate the cutting instrument

to coordinate a cutting stroke with the position of the cutting head relative to a surface having hair extending therefrom.

**9**. The cutting device according to claim **1**, wherein the at least one sensor is configured to send a signal indicating that hair is collected in the cutting head.

**10**. The cutting device according to claim **5**, wherein the computing device is configured to receive a signal indicating that hair is collected in the cutting head and prepare instructions for an operator using the cutting device.

**11**. The cutting device according to claim **10**, wherein the instructions indicate one or more movements of the cutting device for cutting hair to a specified length.

**12**. The cutting device according to claim **10**, wherein the instructions indicate a time to actuate the cutting instrument to coordinate a cutting stroke with the position of the cutting head relative to a surface having hair extending therefrom.

**13**. An automated grooming system, comprising:

a computing device; and

a cutting device comprising:

a handle having a proximal and distal end;

a cutting head positioned near the distal end of the handle, the cutting head comprising:

a cutting instrument, said cutting instrument having a plurality of cutter knives, said cutter knives configured having:

a first surface extending to a second surface and forming a sharp edge therebetween; and

a contoured surface extending from the second linear surface to the first surface;

a comb coupled proximate the cutting instrument, said comb having a first and second end and a plurality of teeth positioned therebetween,

wherein the plurality of teeth and at least one of the first and second end have:

a first surface extending to a second surface and forming a sharp edge therebetween; and

a contoured surface extending from the second linear surface to the first surface;

wherein the angled edges of the cutter knives are configured to slidingly engage the angled edges of the plurality of teeth when the cutting instrument is actuated; and

at least one positioning sensor secured to the cutting device and configured to interact with a positioning device that is configured to be secured to a head of a user and having a positioning interface, said interaction comprising at least one signal indicating the position of the cutting head relative to the positioning interface.

**14**. The automated grooming system according to claim **13**, wherein the computing device comprises a user interface configured to receive inputs from an operator and prepare instructions for the operator,

wherein the instructions indicate a direction in which to move the cutting device.

**15**. The automated grooming system according to claim **13**, wherein the at least one sensor is configured to send a signal to the computing device, the signal indicating that hair is collected in the cutting head.

**16**. The automated grooming system according to claim **15**, wherein the computing device is configured to receive the signal indicating that hair is collected in the cutting head and prepare instructions for an operator using the cutting device.

**17**. The automated grooming system according to claim **16**, wherein the instructions indicate one or more movements of the cutting device for cutting hair to a specified length.

**18**. The automated grooming system according to claim **16**, wherein the instructions indicate a time to actuate the cutting instrument to coordinate a cutting stroke with the position of the cutting head relative to a surface having hair extending therefrom.

**19**. An automated grooming system, comprising:

a computing device;

a cutting device comprising a handle having a proximal and distal end and a cutting head positioned near the distal end of the handle, the cutting device further comprising at least one positioning sensor secured to the cutting device; and

a positioning device comprising:

a frame configured to securely engage with a head of a user;

a plurality of positioning interfaces secured to the frame and configured to interact with the at least one sensor secured to the cutting device, said interaction determining a position of the cutter head relative to the positioning device;

wherein the computing device is configured to

receive a signal from at least one of the positioning device and the cutting device, that relays the position of the cutting head relative to the positioning device,

and prepare instructions for actuation of the cutting device.

**20**. The automated grooming system according to claim **19**, wherein the cutting device comprises a processor configured to receive the prepared instructions from the computing device and actuate the cutting device according to the prepared instructions.

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